WHAT IS CLAIMED IS:

1. A method of processing a semiconductor substrate to form an improved semiconductor device, said method comprising the sequential method steps of:

a first method step of performing a two-stage cleaning process comprising: (i) removing a natural oxide layer formed on said semiconductor substrate; and, (ii) thereafter removing an oxide layer generated by the step of removing the natural oxide layer to produce a cleaned substrate surface;

a second method step of subjecting the cleaned substrate surface to a hydrogen annealing process to form a hydrogen passivation layer and for further reducing the roughness of the cleaned substrate surface;

a third method step of forming a gate oxide layer on the cleaned hydrogen-annealed substrate surface;

a fourth method step of performing a nitridation process on the gate oxide layer formed on the cleaned, hydrogen-annealed substrate surface to reduce the susceptibility of the semiconductor substrate to ion permeation during a later gate electrode forming step; and,

a fifth method step of performing a subsequent thermal process on the nitridation-processed gate oxide layer to stabilize a surface of the gate oxide layer.

2. The method of claim 1, further wherein the oxide layer generated in removing the natural oxide layer in the first stage (i) of the first method step is removed in the second stage (ii) by using HF.

3. The method of claim 1, further wherein the second method step is performed using a thermal process under process conditions of a temperature between about 750°C and 1050°C, a time of about 20 to 60 seconds, at a pressure between about 0.1 and 100 torr, and at a flow rate of about 0.5 SLM to 10 SLM.

4. The method of claim 1, further wherein the nitridation process of the fourth method step forms a protective, ion-impermeable nitride layer on the gate oxide layer.

5. The method of claim 1, further wherein the nitridation process of the fourth method step forms a protective, ion-impermeable nitrogen ion layer in the interior of the gate oxide layer.

6. The method of claim 5, wherein the nitrogen ion layer is formed through a plasma nitridation process.

7. The method of claim 1, further wherein the second method step is performed using deuterium (D_2) instead of H_2 in the hydrogen annealing process.

8. An improved semiconductor substrate prepared by a process comprising the sequential steps of:

(a) treating a surface of a semiconductor substrate at least for removal of a natural oxide layer on said surface to form at least a partially-cleaned substrate surface;

(b) performing a hydrogen annealing step on the at least partially-cleaned substrate surface formed in step (a);

(c) depositing a gate oxide layer on the hydrogen-annealed substrate surface formed in step (b);

(d) subjecting the gate oxide layer of the substrate as formed in step (c) to a nitridation process; and,

(e) thermally treating the nitridation-processed gate oxide layer formed in step (d) to form the improved semiconductor substrate.

9. An improved semiconductor substrate according to claim 8 wherein the surface treatment of step (a) includes the step of treating the surface with an acidic cleaning solution consisting essentially of sulfuric acid, hydrogen peroxide,

and deionized water in suitable proportions.

10. An improved semiconductor substrate according to claim 8 wherein the process of preparing the substrate further comprises a second surface treatment step carried out between steps (a) and (b) for removal of remaining organic pollutants, fine particles, and/or an oxide layer formed during step (a).

11. An improved semiconductor substrate according to claim 10 wherein said second surface treatment includes the step of treating the at least partially-cleaned substrate surface formed in step (a) with a basic cleaning solution consisting essentially of ammonium hydroxide, hydrogen peroxide, and deionized water in suitable proportions.

12. An improved semiconductor device comprising a semiconductor substrate having a gate electrode formed thereon according to the process of:

(a) treating a surface of a semiconductor substrate at least for removal of a natural oxide layer on said surface to form at least a partially-cleaned substrate surface;

(b) performing a hydrogen annealing step on the at least partially-cleaned substrate surface formed step (a);

(c) depositing a gate oxide layer on the hydrogen-annealed substrate surface formed in step (b);

(d) subjecting the gate oxide layer of the substrate as formed in step (c) to a nitridation process; and,

(e) thermally treating the nitridation-processed gate oxide layer formed in step (d) to form the improved semiconductor substrate; and,

(f) forming a gate electrode on the thermally-treated, nitridation-processed gate oxide layer formed in step (e) to form the semiconductor substrate having a gate electrode.

13. An improved semiconductor device according to claim 12 wherein the surface treatment of step (a) includes the step of treating the surface with an acidic cleaning solution consisting essentially of sulfuric acid, hydrogen peroxide, and deionized water in suitable proportions.

14. An improved semiconductor device according to claim 12 wherein the process of preparing the substrate further comprises a second surface treatment step carried out between steps (a) and (b) for removal of remaining organic pollutants, fine particles, and/or an oxide layer formed during step (a).

15. An improved semiconductor device according to claim 14 wherein said second surface treatment includes the step of treating the at least partially-cleaned substrate surface formed in step (a) with a basic cleaning solution consisting essentially of ammonium hydroxide, hydrogen peroxide, and deionized water in suitable proportions.